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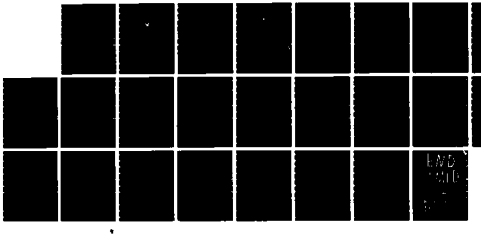

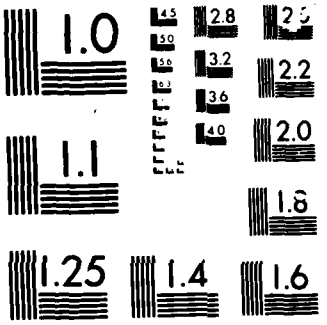

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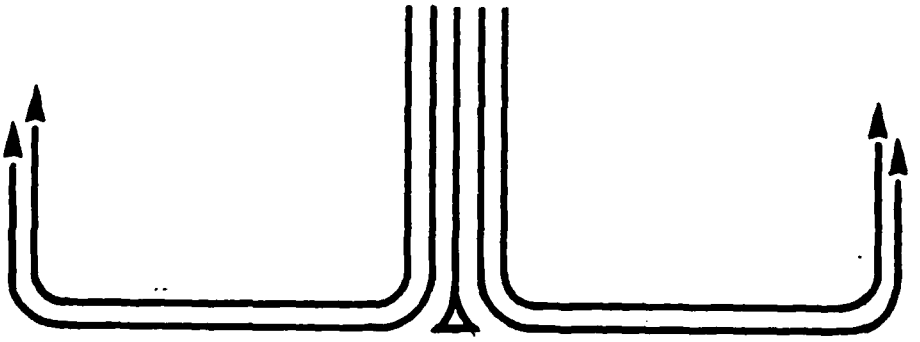
STUDENT REPORT

A USERS GUIDE TO LOCAL AREA NETWORK CONNECTIVITY

MAJ STEPHEN V. BROWN 86-0365

"insights into tomorrow"



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REPORT NUMBER 86-0365

TITLE A USERS GUIDE TO LOCAL AREA NETWORK CONNECTIVITY

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SPONSOR AFSCOASO/DMTC

Submitted to the faculty in partial fulfillment of requirements for graduation.

AIR COMMAND AND STAFF COLLEGE
AIR UNIVERSITY
MAXWELL AFB, AL 36112

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

A166802

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: STATEMENT "A" Approved for public release; Distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): 86-0365	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: ACSC/EDCC; 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State and ZIP Code): MAXWELL AFB, AL 36112	7b. ADDRESS (City, State and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State and ZIP Code)	10. SOURCE OF FUNDING NOS. — PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT NO.
11. TITLE (Include Security Classification): A USERS GUIDE TO LOCAL AREA NETWORK CONNECTIVITY	
12. PERSONAL AUTHOR(S): BROWN, STEPHEN V. MAJOR, USAF	
13a. TYPE OF REPORT; 13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Yr., Mo., Day): 1986 APRIL; 15. PAGE COUNT
16. SUPPLEMENTARY NOTATION	
17. COSATI CODES — FIELD / GROUP / SUB. GR.	18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The users guide on Local Area Network connectivity is designed to provide functional managers with a basic overview of local area networks. Included is information concerning network features regarding functional applications, who the major Air Force players are (MAJCOM and base level), and appropriate justification procedures for anyone attempting connection to a Local Area Network.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☒ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL: ACSC/EDCC MAXWELL AFB, AL 36112	22b. TELEPHONE NUMBER (Include Area Code): 205 293-2483; 22c. OFFICE SYMBOL

DD FORM 1473, 83 APR — EDITION OF 1 JAN 73 IS OBSOLETE.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

PREFACE

I first became interested in the functional aspects of communication networks during my recent assignment to HQ Air Force Manpower and Personnel Center. During my tour there I was involved in developing an office automation system designed to support the existing base level personnel system. The functional definition of the future personnel system included a requirement to interface with every base level functional organization requiring personnel information. My subsequent work with the existing base level personnel system also exposed me to the functional impacts a supporting communications network can have on an operation. Many of the base level automated data systems (ADSs) are currently in a position to redesign their systems to take advantage of the new base level Sperry 1100/60 computers (Phase IV program). Much of the new design work will involve shared data applications requiring communications access to various functional systems. The move towards in-system processing is also being driven by Air Force efforts to get out of the punched card business. The single most cost effective communications networking configuration available to support these new requirements is the Local Area Network (LAN). Unfortunately, LANs do not exist at most Air Force bases and, although cost effective to operate, they can be quite expensive to install, especially if the base cable plant already exists.

This handbook is intended for the functional manager who is confronted with the prospects of LAN connectivity. Although LANs are not currently installed at Air Force bases, they are being designed, and planning for future installations is being done. An organizational structure has been established within the Air Force Communications Command (AFCC) to develop and maintain future Air Force standard LANs. As such, many, if not all, functional systems will eventually be tied together through base level LANs. This handbook will assist the relatively uninitiated (systems wise) functional manager in determining what a LAN can do and who on the base is responsible for LAN operations. It also provides some details needed to justify connectivity to a LAN.

CONTINUED

I greatly appreciate the assistance provided by many people in developing this handbook. In particular, Major Ed Williams, my advisor; Mrs. Joan Bowden, my sponsor; and other members of the staff of the Air Force Small Computer/Office Automation Service Organization, Gunter AFS, AL.

ABOUT THE AUTHOR

Major Brown was commissioned in 1973 through the Reserve Officer Training Corp (ROTC). His first assignment was to McClellan AFB, CA with the Air Force Audit Agency (AFAA). A subsequent assignment with the AFAA at RAF Upper Heyford, UK, exposed him to many of the base level functional organizations. In 1979 he was assigned to the Air Force Institute of Technology (AFIT) and sent to the University of Arizona. Upon graduation he was assigned to the Air Force Manpower and Personnel Center (AFMPC) and began working on a future office automation system for base level personnel offices. He established and monitored several functional prototypes for this new office automation system; collecting and analyzing much of the data used to functionally justify full-scale development of this program. After serving as the Executive Officer to the Director of Manpower and Personnel Data Systems, he became chief of the Base Level Military Personnel System. As such, he was responsible for the day-to-day operation and maintenance of the Base Level Military Personnel System which supports base level commanders and managers with a wide range of personnel data. He holds a BSBA in Accounting from Auburn University and an MS in Management Information Systems from the University of Arizona.

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Chapter One

INTRODUCTION TO LOCAL AREA NETWORKS

One of the most challenging concerns for many functional organizations in today's Air Force is computerization. There currently exist over forty separate automated data systems (ADS) that support functional applications running on the standard base level computer. The tremendous growth in microcomputer technology in recent years has allowed many of the base level functional organizations such as personnel, accounting & finance and maintenance to pursue development of office automation programs. The new functionally automated systems are being built with a wide range of different commercially procured hardware and software. The one requirement that these systems all have in common is the need for communications access to shared information. That means they have to be able to communicate with one another. There are numerous communications networking schemes available today; the one which the Air Force is moving toward to more efficiently cope with the problems of a multi-source systems environment is a Local Area Network.

What is a LAN?

A local area network is a communication facility that covers a limited topology (physical configuration), and interconnects in an effective manner different types of servers (host or mainframe computers) and workstations (distributed terminals), more particularly personal and professional computers. In width it varies from 100 meters to 10 km depending on the architecture. Simply put, local network is a term referring to the total communications environment which connects dissimilar computers or data systems in a specifically constrained area.

You can see the application for LANs at any Air Force Base. The installation of a single communications network that links the base level computers (hosts) to the numerous functionally designed office automation systems (workstations)

has many advantages. First, a common communications network is cheaper than point-to-point architecture and much more efficiently maintained. Secondly, it provides a facility for more efficient office operation through reduced data entry and keystroking. Finally, data system storage and retrieval problems are reduced through access to shared information. The following generalized characteristics help to better define LANs:

- High data transfer rates

- Limited geographic scope

- Equal access by all user devices

- Ease of reconfiguration and maintenance

- Good reliability and error characteristics

- Stability under high load

- Compatibility with a variety of equipment

- Relatively low cost

Now that you have a feel for what a LAN is, we need to describe network configuration or topologies, since that's the part of a LAN that makes it unique from other networks.

Network Topologies

The arrangement of computer resources and communication facilities is known as network topology. Unlike a long-haul network which is designed to support an unconstrained topology, LANs are designed to support a specific topology, i.e., a typical Air Force base. An additional feature that makes LANs unique to other networks is its use of a "broadcasting" versus point-to-point or multi-point topology. Most networks use a central facility to determine where information is to be routed and only the intended receiver gets the message. LANs are designed to "broadcast" information to all users on the network and they in turn determine if the information is addressed to them. The most common LAN configurations in use today are the ring, the star,

the tree, and the mesh.

Ring

The ring network is a pattern of computing elements (nodes) arranged in a circle and connected by a communication medium (link). See Figure 1.1. Communication between nodes is generally uni-directional and must pass from node to node until it reaches its destination. Rings are best suited for environments with a small number of nodes operating at high speeds over short distances.

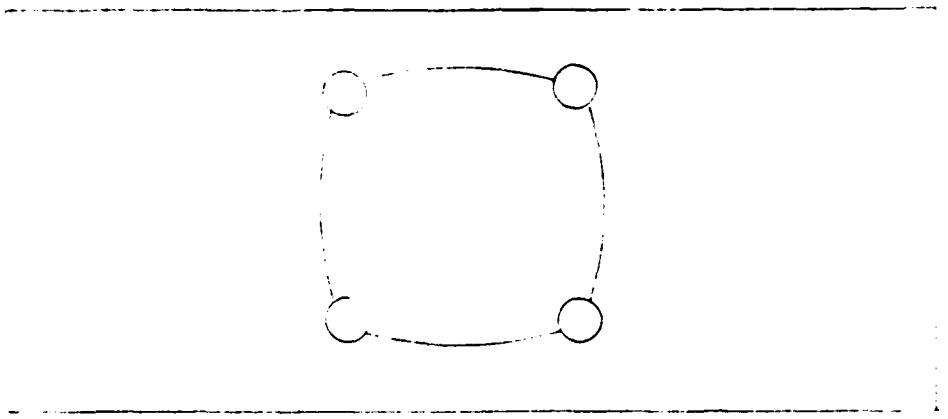

Figure 1.1. Ring Topology

Star

The star network is the only "nonbroadcast" topology currently available as a LAN. The configuration has a central node connected to every other receiving node in the network. See Figure 1.2. All communications control is performed at the central node which essentially acts as a switch-board. Star networks are usually driven by large mainframe systems and can handle a relatively high number of nodes. Potential vunerabilitity stems from the network's entire dependability on the central node to control all communications routing.

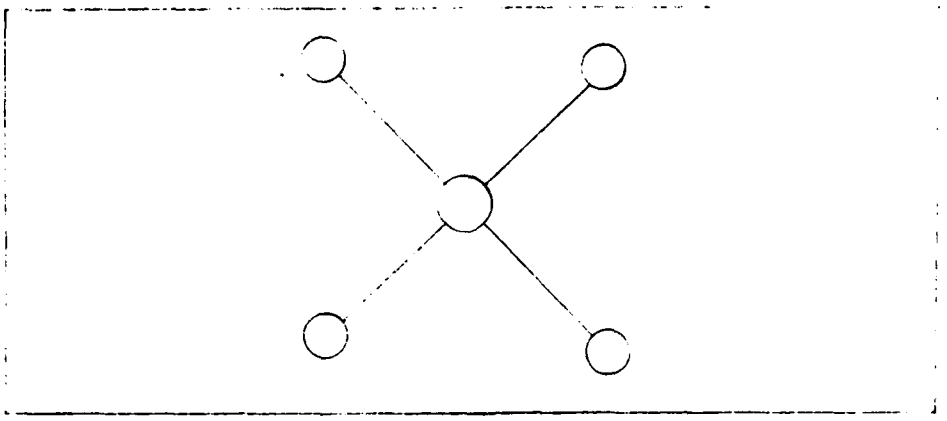

Figure 1.2. Star Topology

Tree

The tree network (also called bus) arranges the nodes like leaves on a tree. See Figure 1.3. The originating node transmits the message along the communications link (bus) and each node reads the address as it goes by. The tree network is probably the most commonly used LAN topology and best serves a large number of nodes over a relatively short distance. One of the major advantages of this configuration is that single node failures have no affect on the overall operation of the network.

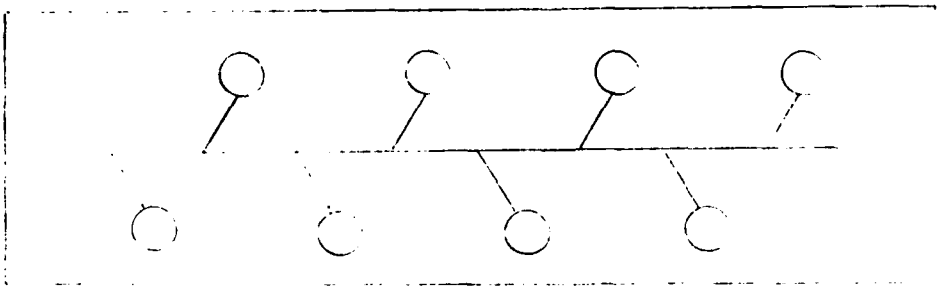

Figure 1.3. Tree (Bus) Topology

Mesh

The mesh network is basically an unconstrained hybrid or nonspecific network. The nodes are connected by patterns which are most economical and can be redundant if required. See Figure 1.4. Mesh networks are not normally used in LANs and are more commonly found in long-haul networks.

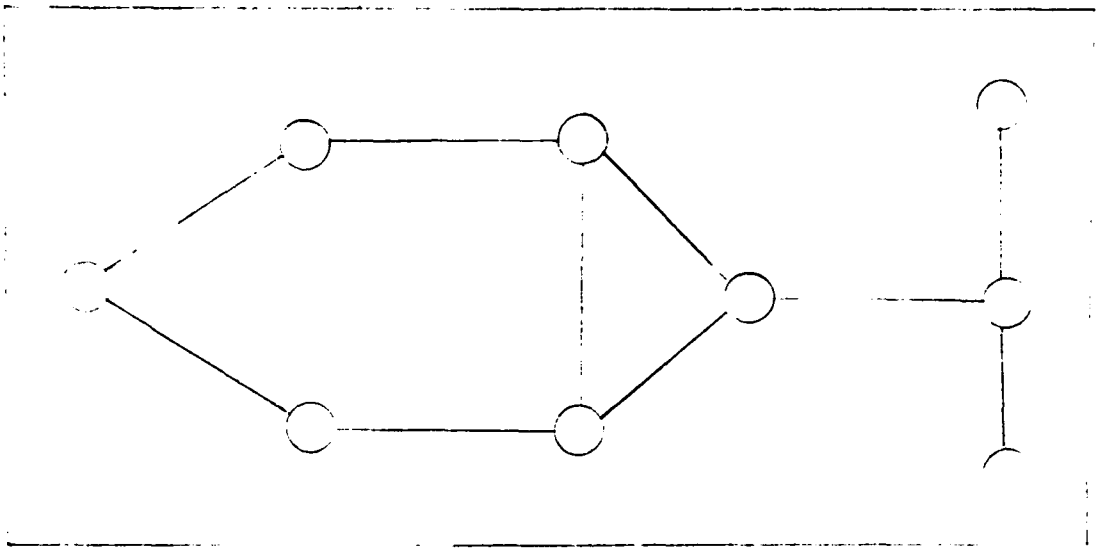

Figure 1.4. Mesh Topology

Alternatives

The trend toward local area networking seems to be driven by two major concerns: (1) interconnectability, and (2) cost. It's relatively easy to see that these two features of LANs are interdependent. The proliferation of computer technology throughout the Air Force is continuing to increase at an exponential rate and requirements for shared information are common place. If all users need access to one anothers data, then using a single common communications line would provide for interconnectability at a reduced cost. However, there are other network configuration that, depending on the

requirement, provide efficient, cost effective communications. Let's look at a few:

Point-to-point - This networking configuration is simply tying two nodes (terminals/computers) together with a single communications line. The advantages are speed (depending on line speed capability) and maintainability. The disadvantages are cost (depending on the number of terminals/computers being connected) and restriction to only one other device. If your system is small with minimum access requirements to a variety of other systems, this configuration is probably most suitable.

Multi-point - This network configuration is designed to take advantage of shared communication lines and supports two or more nodes. The major advantage of a multi-point network is reduced line cost. The disadvantages are reduced speed caused by line contention among the users, and the fact that if the line goes out it takes more than one node down. If your system supports multiple terminals at remote locations and is not dependent on large volume, high speed transactions, a multi-point configuration may be the most suitable.

Chapter Two

INTRODUCTION TO AF LANS AND ALTERNATIVE COMMUNICATIONS

Current Communications Networks at Base Level

The Base Communications Transmission and Distribution System (BCTDS), commonly referred to as the Base Cable Plant, is the collection of all base wire communications media. It handles the operation, maintenance and bookKeeping of base communications wire resources. Most base level communication requirements are met by direct cable link or point-to-point networking schemes. There are also some multi-point networking schemes in use. The concept of a local area network has evolved due to the proliferation of ADP equipment requiring connectivity to numerous other information processing system equipment. Can you imagine the networking nightmare involved with point-to-point communications for every piece of equipment currently being installed to support functional systems?

You may have heard the term DDN (Defense Data Network) at your base. This is a dedicated long-haul communication network providing service from base to base, not intrabase communications. You may have a requirement for interbase communications which will be satisfied by a LAN hook-up to DDN.

Air Force LANs

HQ AFCC and HQ ESD have jointly formed the Air Force Mission Effective Information Transmission System (MEITS), formally known as the Air Force LAN Systems Program Office (AFLANSPO), which has been tasked to develop a unified LAN architecture (ULANA) for the Air Force. In essence what this group is doing is developing a standard family of LAN products for Air Force use. The network will have a broadband (i.e., coaxial cable) distribution system, a family of standard network interface units and a separate network management system. See Figure 2.1.

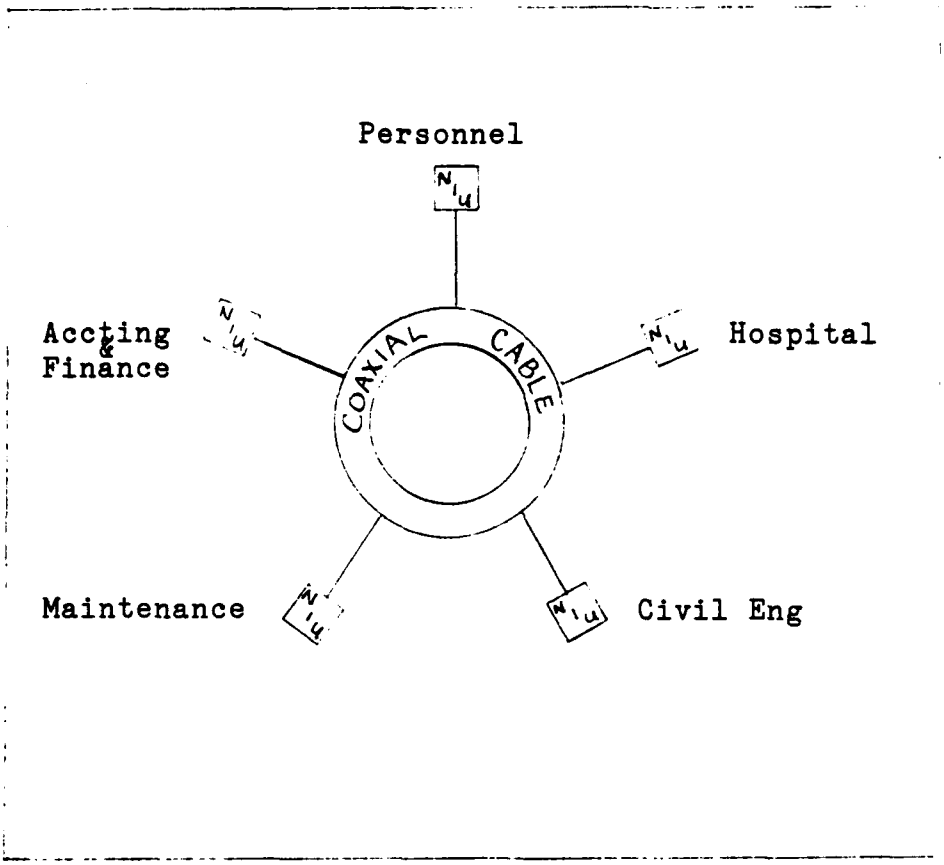

Figure 2.1. View of ULANA LAN

ULANA will provide all the hardware/software required to connect a variety of heterogeneous data, voice and video devices, satisfying most Air Force requirements. Because full ULANA development will probably take several years, plans have been established to procure a standard interim LAN. These interim LANs should be available in 1986 and will provide off-the-shelf network interface units (NIU) for use with existing broadband distribution systems.

The first Air Force operational LAN has recently been installed at Mather AFB. This LAN is scheduled to be

certified in Feb/Mar 86 and is designed to operate as a test bed for functional application prototyping in a LAN environment. It is not ULANA certified, but will allow users at Mather to test future system concepts supported by LAN technologies. The LAN can support over 500 nodes and has been routed to 49 buildings on the base. Currently, both the accounting & finance, and personnel functions are planning to prototype new office automation systems using the LAN as their backbone communications support. The LAN will eventually be tied to the Sperry 1100 host base computer to provide connectivity to existing base level systems.

Future plans are underway to install a second Air Force operational LAN at Moody AFB sometime in late 86. The game plan is to build a fiber optics vice coaxial cable distribution system to support continued functional applications prototyping. The Moody LAN should be operational sometime in CY 87.

Systems Best Suited for LANs?

We've already described several system's features, such as speed (data transfer rates), volume, and interconnectability, which are critical criteria in determining the functional utility of a LAN. Depending on the configuration and how much money is invested, LANs can undoubtedly be designed to support practically any functional application. But who is going to develop a sophisticated LAN to support communications between two common terminals? So the question is, "Do I need a LAN to support my specific application?" In private industry you are going to pay for your network, so that question is critical. In the Air Force you won't be paying for the LAN (if available) per se, but you will have to pay for the system hardware/software required to connect to a LAN. You're also going to pay with systems impacts which are caused by network characteristics. Let's talk about some systems' features which are best suited for LANs.

First, moderate data transfer rates are best suited for LANs; they should not be extremely high. Remember, LANs are shared communication networks with built-in access controls which take time to respond. If you find yourself on a congested LAN network with numerous other functional users,

you're probably going to experience some time delays. If you're operating customer service terminals in the accounting & finance office of the future, and you're waiting thirty seconds for computer responses you'll be paying for the LAN. If your system requires high speed data transfer, direct cable link may be the most cost effective network alternative.

Secondly, systems that deal with a high volume of transactions can experience the same problems as previously described. Although, depending on the particular application, this may not be a problem. If response time is not critical, then delays caused by increased volume are not a problem. However, overall response time for everyone on the network is affected, which will undoubtedly impact the users.

A third consideration is interconnectability. The LAN is a communications network which facilitates electronic connectivity. The one thing it cannot do is interface incompatible functional applications. The substantial benefit of LAN technology is that it provides this interconnectivity with numerous different types of computer equipment. It's therefore best suited for systems having interface requirements with more than one external system that supports compatible applications.

The final consideration of interest in determining LAN utility is system expansion. As a rule of thumb, LANs can more beneficially support systems that are expanding or being reconfigured. Adding terminals to a LAN supported system is almost as easy as plugging in your typewriter. On the other hand, adding terminals to a system supported by a point-to-point network configuration requires starting from scratch and installing all required connections.

In summary, if you have a dynamic system requiring interconnectivity with several other systems and can live with some response time degradation, then a LAN could provide a cost effective communications alternative.

Chapter Three

AIR FORCE LAN OPERATIONS

Air Force LAN Operations

Now that you have a feel for what a LAN is, what it can do, and what's available in the Air Force, let's talk about who's in control. There are several key players at base level that can get you up to speed on what's available at your specific base, but before we introduce them, let's talk about the command players.

HQ AFCC

AF Communication Command has the overall responsibility for guidance and direction in LAN planning. They're responsible for design, development, acquisition, implementation, operation, and maintenance of all Air Force communication networks, including LANs.

HQ ESD (MEITS)

You were introduced to this organization in Chapter Two. Remember, they're the folks who have been tasked with developing a standard Air Force LAN architecture.

Base Information Digital Distribution Systems Program Office (BIDDSPO)

This office is under the direction of AFCC and has assumed responsibility for implementation of ULANA. The MEITS organization has direct responsibility for the development of ULANA and will pass the project to the BIDDSPO for Air Force implementation.

Electronic Installation Division (EID)

These folks are at Oklahoma City, OK and act as the focal point for implementation of LANs Air Force-wide. They're known as the Implementation of LANs (ILAN) Program Management Office and are basically responsible for integrating all major components of LANs. You won't be dealing with them unless you're the LAN manager at your installation.

Standard Information System Center (SISC)

Formally known as the AF Data Systems Design Center at Gunter AFS, AL, they provide technical assistance to other LAN players. The Air Force Small Computer/Office Automation Service Organization (AFSCOASO), as part of the Data Systems Design Office, is the organization chartered to prepare technical specifications for network interface. They also manage the Gunter LAN as part of the AFCC test bed for LAN developments.

Base Level LAN Players

We've just described the organizations basically responsible for design and development of future AF LANs. As a functional manager of a system, your contacts with these organizations will be minimal. The base level organization charged with the responsibility for the day to day operation of communication networks is the Information Processing Center (IPC).

IPC

The Information Processing Center is the new squadron level organization which incorporates the old communications squadron and the data automation function (Data Processing Installation, DPI). Their job basically entails management of communication and data automation facilities. This is the organization you'll have to deal directly with in developing and implementing specific LAN connectivity requirements. By the way, they do have specific responsibilities to you as a customer. AF Regulation 700-7 section D outlines IPC

responsibilities in the area of customer support. After a generic description of customer support, they are charged with providing customers training on the use of available information systems and providing customer education on available services. If and when LAN technologies arrive at your particular installation, these are the folks who can tell you what is available and provide detailed information as to required systems specifications for network connectivity. There is one other critical player you should be aware of, the LAN manager.

LAN Manager

During the initial prototype phase of Air Force LANs the primary figure in LAN development and operation has been the LAN manager. Although no current authorizations exist for a LAN manager per se, you should be able to find someone who wears the title at the Information Processing Center. The LAN manager will be basically responsible for day to day LAN operation and should serve as a point of contact for functional managers interested in connectivity. More likely, this is the individual who will review and assess functional requirements and justification for LAN support. Chapter Five will explain the current functional justification process.

Chapter Four

CRITERIA ESSENTIAL FOR CONNECTIVITY TO A LOCAL AREA NETWORK

This chapter is designed to provide you, the functional manager, with a limited background concerning network connectivity criteria. Although it's certainly not necessary for a manager to understand details of how data is transmitted through the network, or what hardware and maintenance considerations are critical, general knowledge of these areas can arm you with enough information to ask the right questions to those people who are designing and implementing your system.

Standards and Protocols

The term standard is basically just what it implies - the common use of a particular function, code, or piece of equipment, throughout an industry. An important concept to understand is the electrical standard. Computers communicate internally and externally via digital signals. Electrical voltages are used to determine bits of information, which are then processed by computer systems. Each system has a specific voltage level which must be maintained within a standard range in order to interface with each other. The most common industry standard code for this electrical current is the Electronic Industries Association RS-232-C. This code provides a common description of what the signal coming out of and going into a computer/terminal will look like.

Another concept you need to be aware of is the difference between asynchronous and synchronous transmissions. When information is transmitted there needs to be a way to indicate the start and stop of each transmission. Asynchronous transmissions attach a start and stop flag to each character of information transmitted. Synchronous transmissions add a start and stop flag to a continuous stream of characters. Synchronous transmission is faster, and better serves high speed transmission systems, but obviously requires more precise timing which is controlled with additional

communications software.

The final concept involved in data transmission that you need a basic understanding of is communication protocols. Protocols are communications software that handle information addressing, identification of message termination, and message accuracy validation. Protocols are standardized so that interfacing users can decipher information being transmitted to each other. If standard protocols are not used you can see that systems which are interfaced via communication facilities would still be incapatible. It's also important to note that protocols are designed to facilitate transmission of information between stations as well as controlling the overall information flow or routing on the network.

Hardware Considerations

Let's take a look at the hardware involved in supporting connectivity to a LAN. Assuming the LAN has been implemented and a drop point has been installed at your facility, the only additional hardware requirement for connection to the LAN is for a Network Interface Unit (NIU). The NIU is a "black box" containing physical connectors and software which provide the necessary protocols to allow external equipment to be connected to the LAN. Remember, equipment that does not support the industry standards discussed above, is extremely difficult to interface with other non-standard equipment. Current Air Force plans are to authorize NIUs as a Table of Allowance equipment item. The size and cost of the NIUs vary with the number of connectors and amount of software provided. As a Table of Allowance item the cost of the NIU will be borne by the user.

Another hardware consideration concerning LAN connectivity is a LAN to LAN connection. If your functional system is already supported by a LAN, for instance, the accounting & finance office automation system may be supported by a small LAN within the accounting & finance office, you may require a gateway processor. This processor houses additional software and memory capacity for interfacing dissimilar LANs. The additional software and memory could be embedded in the NIU or your host computer system, but it has to be part of your checklist regardless of where it is housed.

Security Considerations

The state of the art in LAN technologies would make processing classified information across the network too risky. Depending on the transmission media, i.e., wire, coaxial cable or fiber optics, differing levels of security can be obtained. Coaxial cable, which is currently the most common media used, requires a physical tap into the network in order to intercept or destroy information being transmitted over the network. Encryption devices would make it difficult to effectively intercept the information, but would not stop intruders from destroying information. Normal password protection schemes built into existing software can protect the integrity of systems residing on separate host computers and periodic security analysis functions can be performed on data processed over the network.

Although the first Air force LANs will not support classified processing, they will provide enough security to process the bulk of the Air Force's data transmission requirements.

Maintenance

As you know by now, LANs are generically considered as communication systems and not as an extension to a vendor specific system. Therefore, maintenance responsibilities will rest with the organization implementing the LAN. The Information Processing Center will be responsible for maintaining base level LANs installed by HQ AFCC. One consideration you must be aware of is that if you purchase a LAN to support a user specific system, i.e., accounting & finance's office automation system might be supported by a small LAN within the accounting and finance function, then, you the user, will probably be responsible for maintenance.

Another important consideration involving maintenance of LANs is obviously the type of LAN and topologies used in configuration of the LAN. Some LANs are more reliable than others, the difference being type of transmission media, i.e., wire, coaxial cable or fiber optics, and amount of hardware and software necessary to operate the LAN. LANs in general can be configured to provide users greater network reliability

than point-to-point or multi-point networks. In most cases, breaks in the transmission media for LANs are easy to find and fix compared to todays cable plant problems of having to single out one or two wires from a cable housing several hundred.

Installation/Connection

Several considerations must be carefully reviewed involving facilities modifications before a user can connect to a LAN. First, does the base cable plant already provide communications support to your facility? Is the LAN routed to your facility? If the answer is no, then you need to submit an Information Systems Requirement Document (ISRD) to the Information Processing Center requesting your facility be established as a LAN drop site. You should do this as early as possible; from past experience, it can take up to a year for communications support at some installations. Facilities modifications required to support automated systems depend primarily on the size and power of the system being installed. Modifications range from additional electrical circuits to increased air conditioning. The point here is that communication requirements are part of that checklist, and need to be worked early in the game. It is extremely frustrating to have your entire system ready to go and then find out you don't have a communications line in your building that will reach the LAN.

Chapter Five

REQUIREMENTS JUSTIFICATION

If you've read the first four chapters, then you probably have a basic understanding of Local Area Networks, what they can do, and some of the considerations involved in their operation. Now it's time to find out how the justification process works.

Functional Requirement

The first thing required in this process is to determine if a LAN is really required to functionally support your particular data system. As previously mentioned, your system may already be optimally supported with the current communications network. So, let's list some of the basic functions that a LAN should support. The typical applications include: electronic mail and calendar management, word processing, facsimile, data entry and voice mail. Some other functional requirements that LANs should support include growth potential and access to other networks.

For starters, you should analyze the requirement by defining your objectives. What is your system supposed to do? Are you an information processing operation, providing information to other users; or are you retrieving information from other sources? You may find that determining the information needs of your organization in terms of production, storage and uses is helpful in defining your objective. Secondly, describe the system. Outline the information flow of your system. What organizations are part of this information network? Outline functional requirements for specific information. For example, personnel rosters specifying required immunizations are generated from the base level personnel system and provided to the hospital. Once immunization information is updated at the hospital, it's returned to the personnel system and maintained on file for further use. A description of your information network can really help you nail down your functional requirements. The

final consideration in justifying access to a LAN is to determine communication needs. Although not a functional requirement associated with your system, communication needs should be outlined in terms of compatibility and capacity. Compatibility is defined here in terms of system compatibility, i.e., personnel and accounting & finance may have a communications link connecting them, but it does no good unless the systems are compatible. You'll also need to determine how much information is being transferred. You may recall in chapter 2, we discussed transfer rates impacting on the functional ability of a system. Remember, defining your system objectives, describing your information network, and determining your communication needs are all critical components in your ability to functionally justify your systems connectivity to a LAN.

Justification Process

The justification process for LAN connectivity is described in AFR 700-3, chapter 2. It basically states that an Information Systems Requirement Document (ISRD) must be submitted by the functional user. The ISRD identifies and describes the required capability, justifies the need, and serves as the validation and approval document. Details for completing a ISRD (AF Form 3215) are found at Attachment 1 of AFR 700-3 and require the following information for justifying the need:

- Major functional objectives
  -- Describe your organizational responsibilities in terms of information requirements. Explain what your system does and why.

- Mission impacts if requirement not supported
  -- Here's where you want to describe the functional impacts, i.e., accounting & finance mission is delayed, duplicated or not accomplished because access to certain information from the personnel system is not available. Are you doing manual work because in-system information is not available?

- Tangible benefits
  -- Relate functional and system benefits associated with connection to the LAN. Productivity increases, if

quantifiable, should be included.

- Improvements in capabilities
  -- This ties directly to tangible benefits and increased productivity. It also includes being able to provide more accurate, timely information to those requiring your services.

- Identify cost savings
  -- Can your system do the job with less equipment through more efficient communications access? Is the LAN less expensive than your current communications configuration or other alternatives? Here's where you can try to put a price tag on increased productivity and other tangible benefits.

- Identify required system interfaces
  -- Describe interface requirements in terms of functionality. If you have a current manual interface which could be automated if the communications link existed, it should be included in this identification process.

- Any additional systems development necessary to support requirement
  -- As a functional person you'll probably need some help on this one. If the folks at the IPC draw a blank, have them contact your functional system developer at SISC, Gunter AFS, AL.

- Alternatives
  -- Lay out any alternatives that you're familiar with. If you've done your homework, the only reasonable alternative will be connection to a LAN.

Approval authority for LAN connectivity has been established at the MAJCOM and MEITS level. Currently procedures will require the ISRD to meet the Information Systems Requirement Board at your specific installation and if validated, forwarded to MAJCOM and MEITS for approval and overall management and coordination of user LAN requirements.

The base information systems staff officer or base level LAN manager located at the Information Processing Center should be able to assist you in preparing the ISRD.

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